Considerations for Restoration of Submersed Aquatic Vegetation in Currituck Sound

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Discussion Topics

- ✓ **Coastal Ecosystem Restoration: An Evolving Science**
- ✓ **Planning Consideration for Coastal Restoration**
- ✓ **Restoring SAV in Currituck Sound : An Acid Test**
  - **Experts**
  - **Site Selection Consideration**
  - **Plant Considerations**
  - **Modeling**
  - **Logistic Consideration**
- ✓ **Example SAV Projects in NC**

Ecosystem Restoration: An Evolving Science

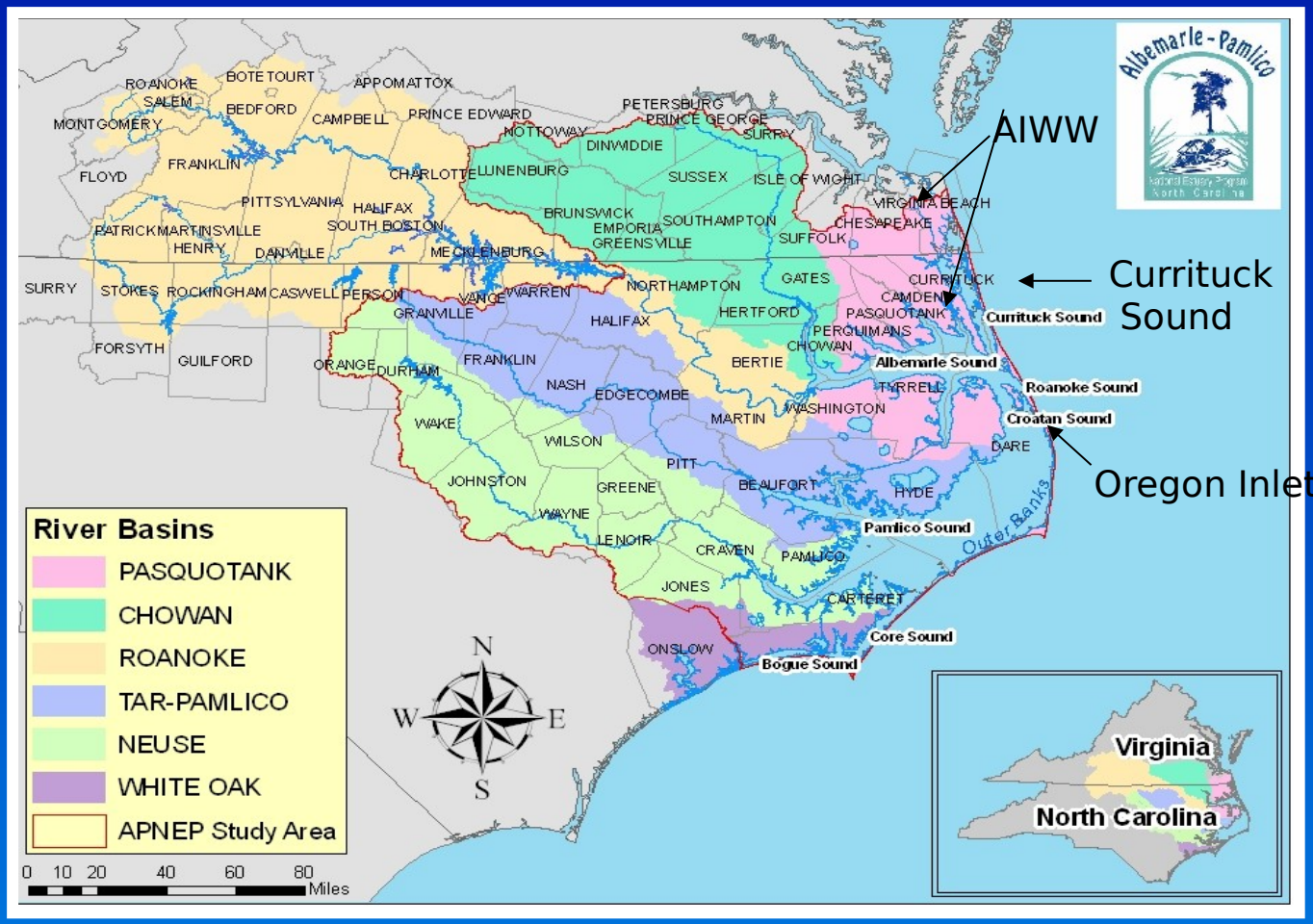
Planting ⇒ ***Habitat Construction*** ⇒ ***Ecosystem Restoration*** ⇒ ***Much to Learn***

Restoration Planning Considerations

Identify Goals ➡ Identify Sites ➡ Appropriate Sp

- **Nutrient Removal**
- **Sediment Toxicant Removal**
- **Aquatic Diversity/Abundance**
- **Shoreline Stabilizati**
- **Aesthetics**
- **Wildlife Habitat**

Albemarle-Pamlico National Estuarine System Watershed

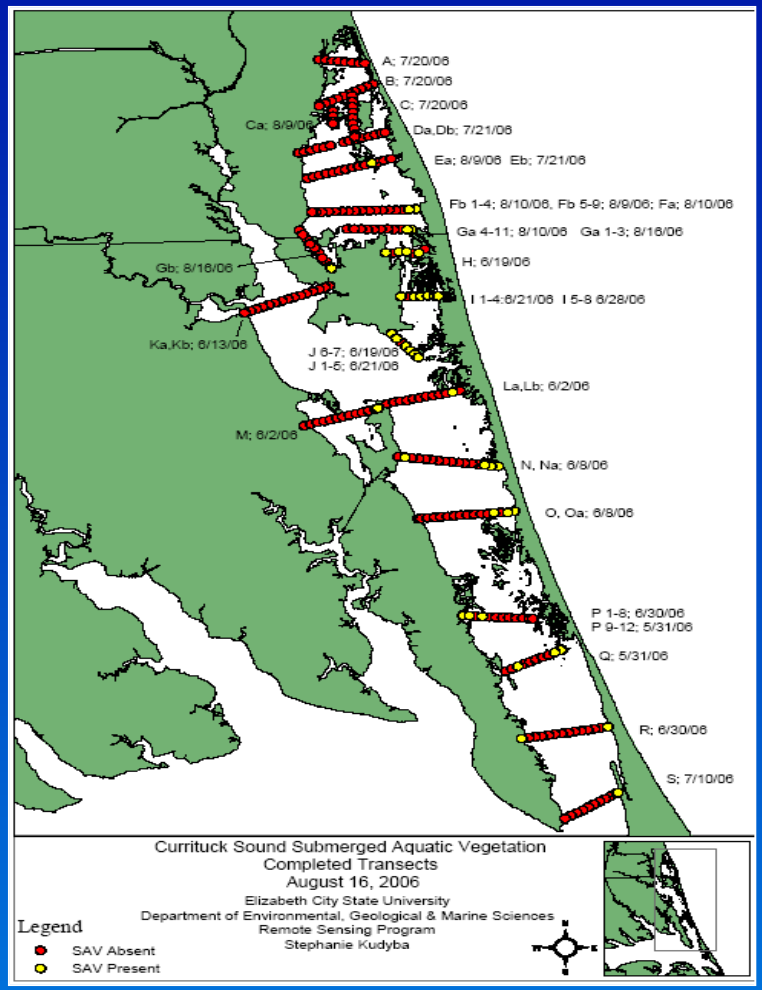


SAV Experts

- ✓ **High Salinity SAV, NMFS SAV :** Dr. Mark S. Fonseca, NOAA Fisheries
- ✓ **Low Salinity Submersed Grasses**: Dr. Kenneth A. Moore VIMS
- ✓ **Chesapeake Bay restoration,** Drs. Deborah Shafer & Steve Ailstock
- ✓ **Optical model:** Jud Kenworthy NOAA
- ✓ **Back Bay SAV study:** Cindy Kane USFWS
- ✓ *Rhizoctonia* **fungus:** Drs. Marc A. Cubeta & Carl R. Crozier,. NC State, Judy Shearer ERDC, Jan Kohlmeyer UNC Institute of Marine Sciences
- ✓ **Wilson Bay SAV restoration:** Pat Donavan-Potts City of Jacksonville
- ✓ **Potential state wide SAV propagation**: Dr. Kimberly Jones, Brunswick Community College & JP Mc Cain Sturgeon City
- ✓ **SAV Field Conditions and Mapping:** Jill Paxson DWQ, Scott Chappell NCDMF
- ✓ **SAV Restoration, propagation of Ruppia:** Michael J. Durako, Professor UNCW
- ✓ **SAV Work Group (14 Members), APNEP, CHPP**

Considerations for Site Selection **Physical Conditions**

- **HYDROLIGY**
  - Non-tidal
  - Tidal (Lunar tide, or wind driven tide)
- **WATER QUALITY**
  - Salinity
  - Clarity, (TSS, Color, Chlorophyll)
  - Nutrients (Dissolved Inorganic Phosphorus and Nitrogen)
- **SOILS**
  - Muck Soils
  - Sandy soils
- **ENERGY REGEIME**
  - Location relative to prevailing winds
  - Fetch
  - Bottom topography



Considerations for Site Selection

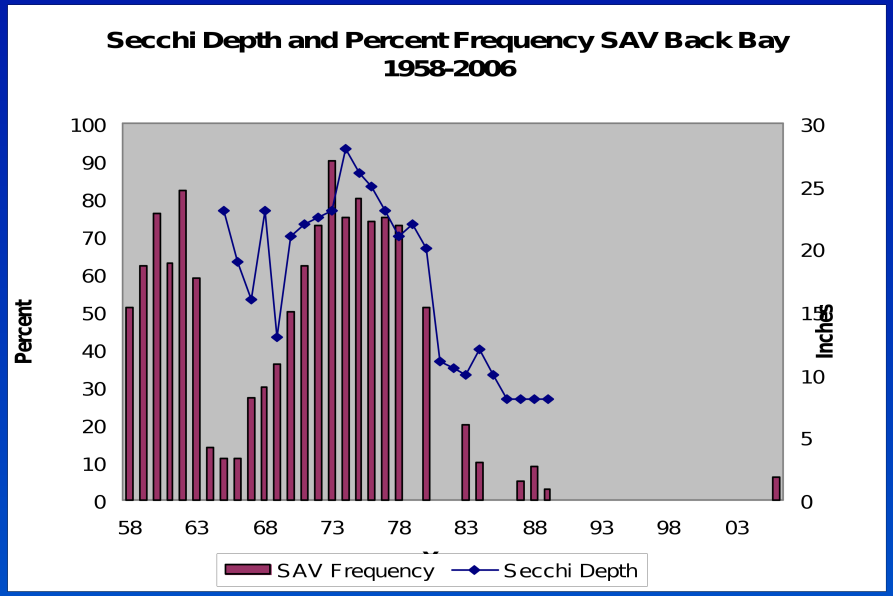
- **HUMAN FACTORS**
  - **Adjacent Land Use**
  - **Storm water or Sewage Drainage**
  - **Shoreline Erosion Turbidity and Burial**
  - **Dredging of Navigation Channels**
  - **High Human Recreational Activities**
  - **Hydrologic Modifications**
    - Channels, locks
    - Flow Regulation (Dams)
    - Restrictions, (Bridges, Causeways, Dune Building)
    - Salt or fresh water discharge
- **BIOLOGICAL FACTORS**
  - **Waterfowl**
  - **Carp**
  - **Nutria**
  - **Plant Fungus ?** *Rhizoctonia solaniia*

SAV Habitat Requirements

Salinity Regime	Growing Season	Light @ Leaf	Water Column Light	TSS mg/l	Clorophylla *u* g/l	P mg/l	N mg/l
Tidal	April - October	>9%	>13%	<15	<15	<0.02	None
0.5 -5.0 Fresh	April - October	>9%	>13%	<15	<15	<0.02	None
5.0 -18	April - October	> 15%	>22%	<15	<15	<0.01	<0.15
5.0 -18	Mar- May Sept - Nov	> 15%	>22%	<15	<15	<0.02	<0.15

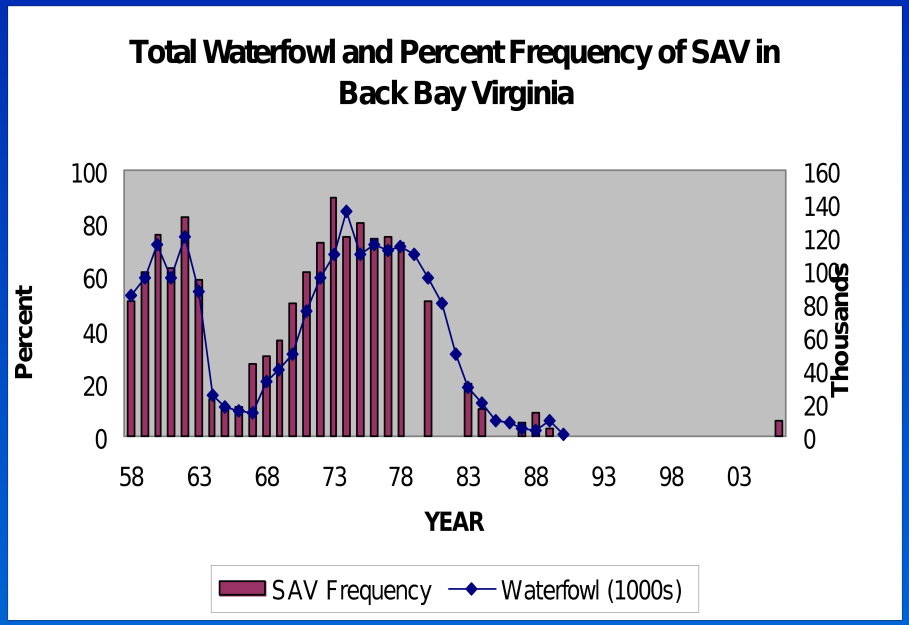
Recommended primary and secondary SAV habitat requirements for the Chesapeake Bay for various salinity regimes. [Source: Funderburk et al. 1991; EPA 2000]

SAV Ecological Relationships



SAV responds to changes in water clarity - biofeedback

Data from Settle and Schwab, VDGIF 1990 & ECSU 2007



Waterfowl respond to food availability

Considerations for Plant Selectio

SAV species	Environmental parameter					
	Salinity (ppt)		Secchi depth m (ft)		Water depth m (ft)	
	Range	Average	Range	Average	Range	Average
HIGH SALINITY SEAGRASS						
Eel Grass	10 - >36	26	0.3 - 2.0 (1.0 - 6.6)	1.0 (3.3)	0.4 - 1.7 (1.3 - 5.6)	1.2 (3.9)
Shoal Grass	8 - >36	25	0.4 - 2.0 (1.3 - 6.6)	1.0 (3.3)	0.1 - 2.1 (0.3 - 6.9)	0.8 (2.6)
Widgeon Grass	0-36	15	0.2 - 1.8 (0.7 - 5.9)	0.7 (2.3)	0.1 - 2.5 (0.3 - 8.2)	0.8 (2.6)
LOW SALINITY SEAGRASS						
Redhead Grass	0-20	1	0.4 - 1.4 (1.3 - 4.6)	0.9 (3.0)	0.4 - 2.4 (1.3 - 7.9)	0.9 (3.0)
Wild Celery	0-10	2	0.2 - 2.0 (0.7 - 6.6)	0.6 (2.0)	0.2 - 2.3 (0.7 - 7.6)	1.0 (3.3)
Eurasian Watermilfoil	0-10	2	0.2 - 1.4 (0.7 - 4.6)	0.6 (2.0)	0.5 - 2.4 (1.6 - 7.9)	1.1 (3.6)
Bushy Pondweed	0-10	1	0.2 - 2.0 (0.7 - 6.6)	0.7 (2.3)	0.5 - 1.7 (1.6 - 5.6)	1.0 (3.3)
Sago Pondweed	0-9	2	0.2 - 0.4 (0.7 - 1.3)	0.3 (1.0)	0.6 - 0.9 (2.0 - 3.0)	0.8 (2.6)

Average environmental conditions at locations where submerged aquatic vegetation occurred in coastal North Carolina, 1988-1991. [Source: Ferguson and Wood 1994)

Other Considerations

- Infrequent Natural Events
  - Hurricanes
  - Droughts
  - Floods
  - Hard Winters

WQ Modeling Scenarios

- ✓ **Nutrient Loading**
  - Point source
  - Impervious surfaces
  - Agriculture influences
  - Channelization of Joyce Creek
- ✓ **AIWW**
  - Hydrologic effects
  - Discharge of Suspended Solids
  - Locks
- ✓ **Ocean Salinity Intrusion**
  - Historic inlets
  - Wash over
  - Pumping into Back Bay

WQ Modeling Scenarios

- ✓ **Albemarle Sound Inputs**
  - Dredging New River
  - Changes to Roanoke River – Dams, Flows
- ✓ **Other influences**
  - Blockages at the Narrows
  - Bridges – Roanoke Island, Outer Banks, Wright Bridge
  - Croatan Sound restrictions
  - Dredging Oregon Inlet
  - Wind fetch effects
  - Rising sea levels

Optical Model

Seagrass Siting Model to *Establish Suitable Sites*

- **Suitability based on factors that drive eelgrass biology coupled with available geospatial data.**

- **Five data layers identifying suitable sites**
  - Bathymetry (depth)
  - Temperature
  - Light attenuation
  - Current eelgrass location
  - Historic eelgrass location

NOAA Tidally Corrected Optical Water Quality Model

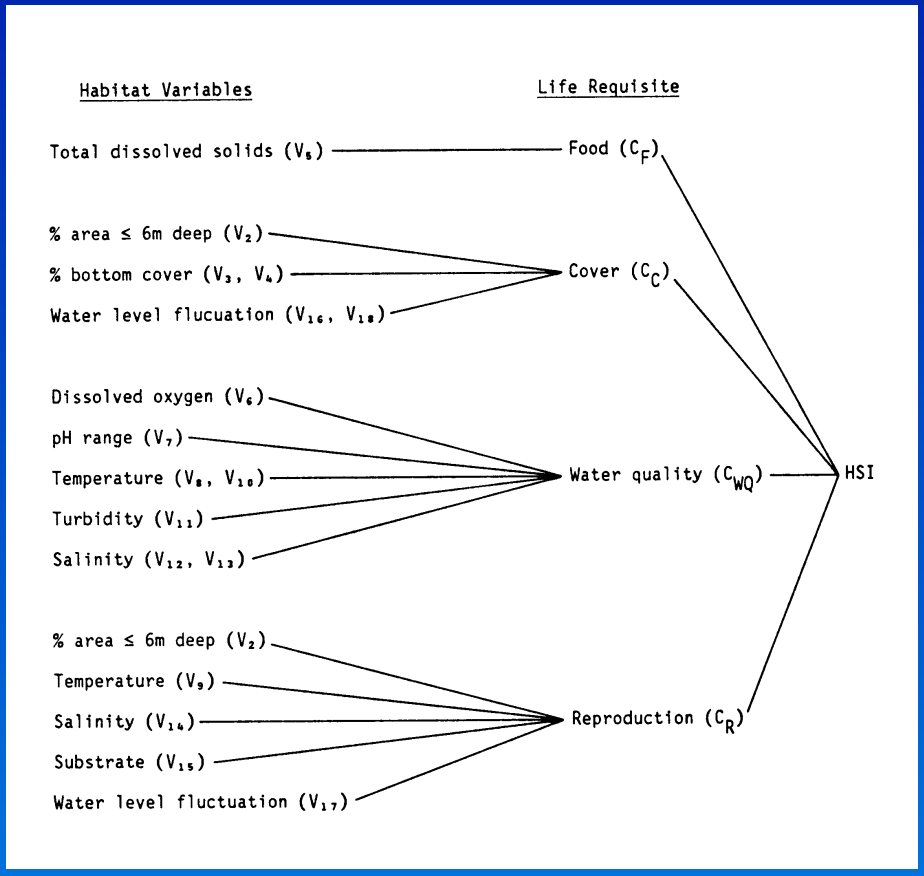
- The amount of light reaching seagrass is the product of several factors
  - Epiphytes
  - Water depth
  - Turbidity.
    - **chlorophyll a,**
    - **suspended particulate matter (SPM)**
    - **colored dissolved organic matter (CDOM)**

NCCOS WAVE EXPOSURE MODEL (WEMo)

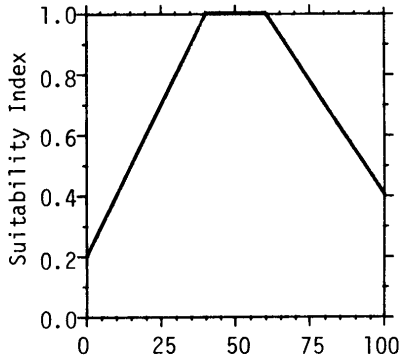
Relative Exposure Index (REI) for each of the major eight compass headings

- **Wind speed**
- **Frequency of wind**
- **Fetch**

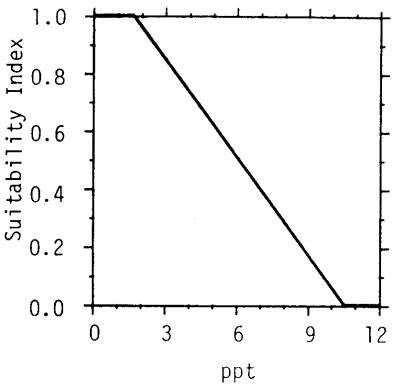
Habitat Suitability Index
Largemouth Bass



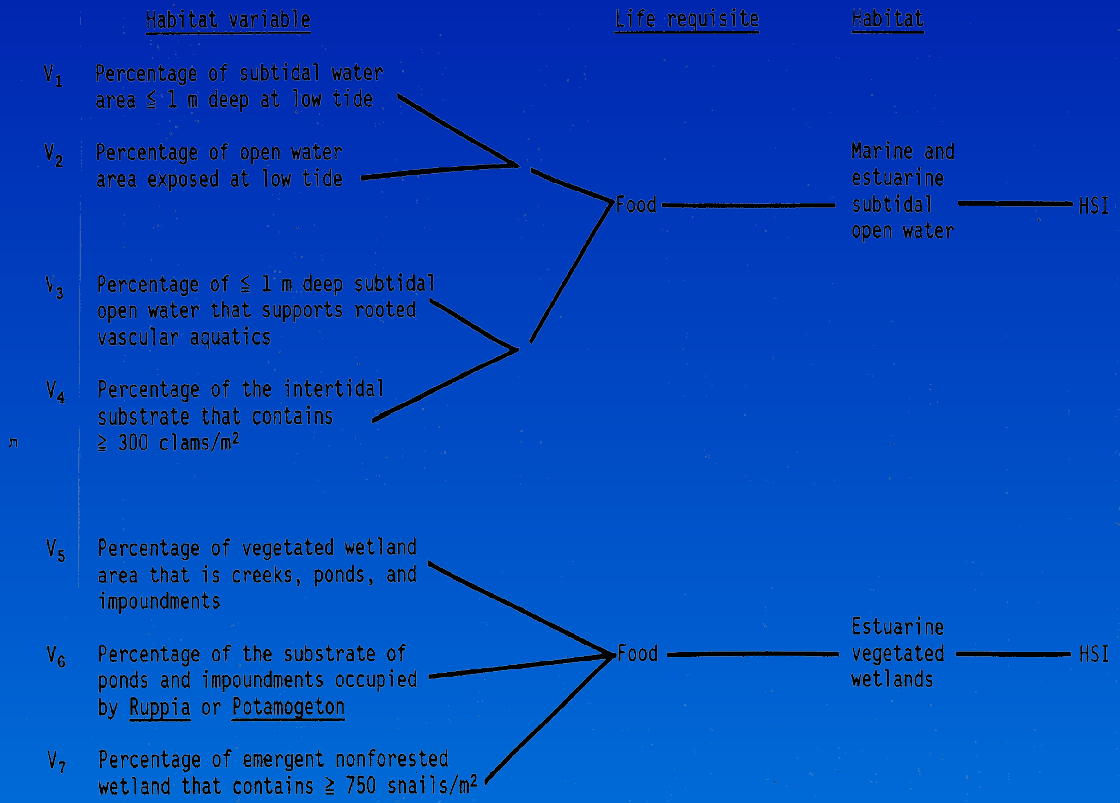
Percent bottom cover (e.g., aquatic vegetation, logs, and debris) within pools, backwaters, or littoral areas during summer. (Adult, Juvenile)

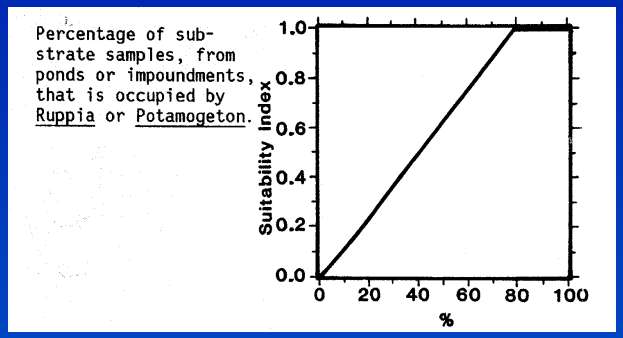


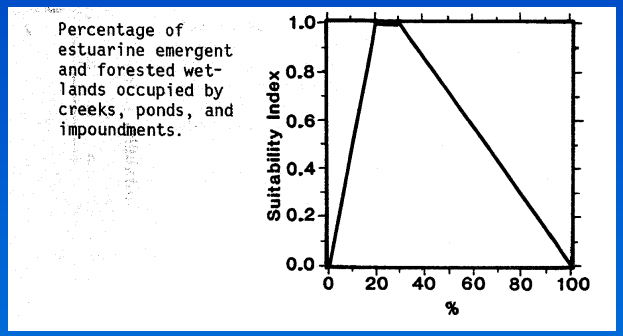
Maximum salinity during spawning and incubation. (Embryo)



Habitat Suitability Index
American Black Duck


Habitat variable
Life requisite
Habitat
V1 Percentage of subtidal water area ≤ 1 m deep at low tide
V2 Percentage of open water area exposed at low tide
V3 Percentage of ≤ 1 m deep subtidal open water that supports rooted vascular aquatics
V4 Percentage of the intertidal substrate that contains ≥ 300 clams/m²
Food
Marine and estuarine subtidal open water
HSI
V5 Percentage of vegetated wetland area that is creeks, ponds, and impoundments
V6 Percentage of the substrate of ponds and impoundments occupied by Ruppia or Potamogeton
V7 Percentage of emergent nonforested wetland that contains ≥ 750 snails/m²
Food
Estuarine vegetated wetlands
HSI





Logistic Considerations

SAV RESTORATION OPTIONS

- Remove Stressors
  - Protective Structures
  - Hydrologic Modifications
  - Nutrient, or Sediment Reductions
- Allow Natural Colonization
  - Not appropriate if exotic plants are a threat
- Planting
  - Methods (Transplants or Seeding)
  - Logistic Considerations
    - Local Genotypes
    - No NC vendors
    - Native transplants concern especially for mitigation

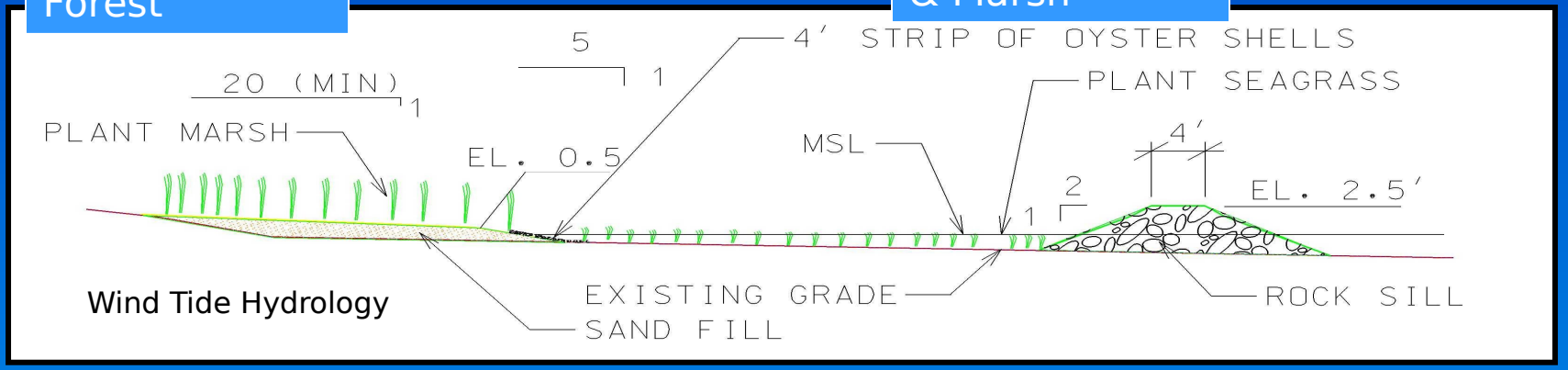
ival Park Shoreline Restoration

Remove Stressor and Allow Natural Colonization

Maritime Forest

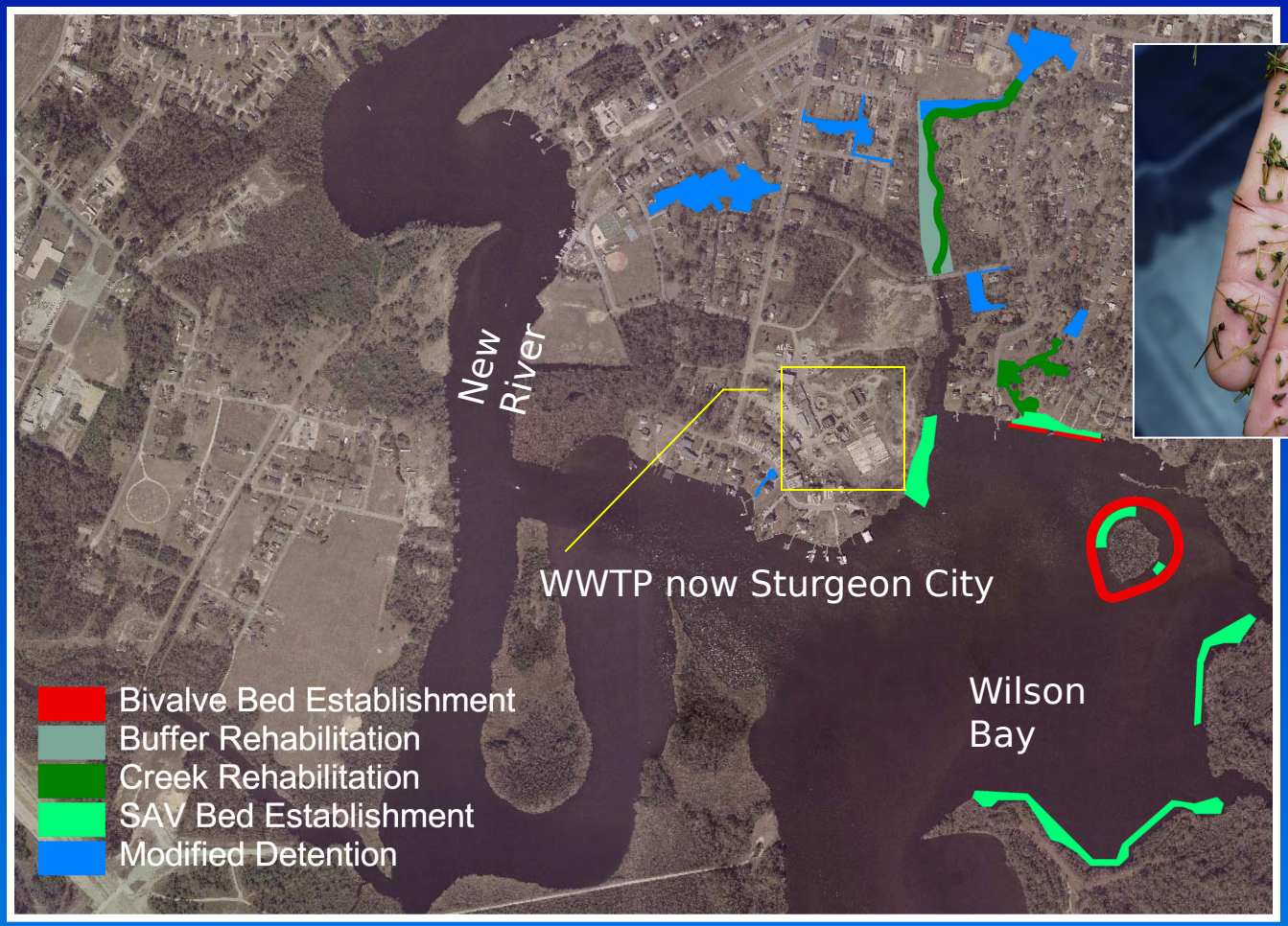
Living Shoreline SAV & Marsh

Oyster Reef



Wilson Bay Ecosystem Restoration

Remove Stressors and Plant Seeds and Plugs



Wilson Bay *Ruppia maritima* Seed Harvest and Production

Collect Seed Bearing Stems (Summer Year 1)

Floating Bags Deployed (Summer Year 1)

Isolate Seeds (Summer Year 1)

AACC Testing/Cold Storage (Summer/Winter Year 1)

Containers to Sturgeon City (Spring Year 2)

Broadcast Seeds (2 seeds/SF) (Spring Year 2)

Plant seeds in peat pots in drying beds and then transplant (Year 2)

3 week collection window (ERDC Photo)

Photo Credit Dr Ailstock AACC

Seed Processing & Storage

Large volumes of reproductive plat material

- New logistical and technical challenges
- Isolate mature seeds from the stems

Processing Tanks

Small Scale

Large Scale

Storage Tanks

Slide adapith from Shafe ERDC. Seed processing equipment. Left, large-scale outdoor seed processing tanks for *Z. marina* (Photo by VIMS**). Right, wringer washing machine provides agitation to facilitate seed separation** (Photo by S. Ailstock)**. Eelgrass seed storage facilities at VIMS**

Seed Planting

Seed Broadcasting : Eelgrass seed broadcasting effective seeds rapidly incorporate & do not move far from where they settle (Orth et al. 1994).

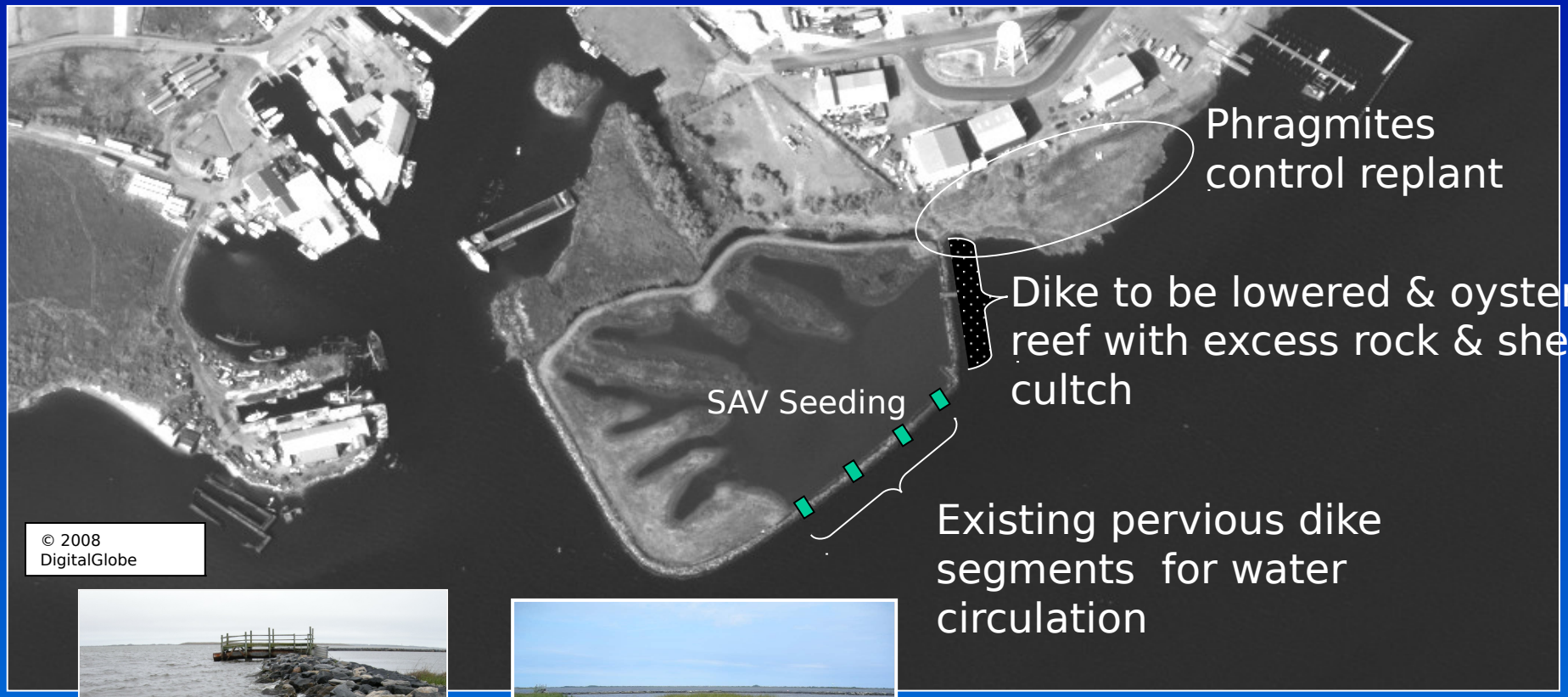
Manual Seed Broadcasting: low tech, low cost slow, even seed distribution difficult to achieve

Mechanized Seed Broadcasting: capable of evenly dispersing seeds at suitable densities (100,000 - 300,000 seeds/acre) at the rate of 10 minutes/acre.

Slide adapted from Shafer ERDC

Wanchese Marsh Creation

Ruppia Seeding


Phragmites control replant
Dike to be lowered & oyster reef with excess rock & shell cultch
SAV Seeding
Existing pervious dike segments for water circulation
© 2008 DigitalGlobe

Seed Dispersal

Photo by MDDNR

Photo by VIMS

Seed Buoys (“Pickerell bags”) Pickerell et al 2005; 2006)

Pros: Mimics natural dispersal patterns, low cost, low tech, no expensive seed separation and storage required, avoids potential problems with seed mortality in storage, and swell-suited to volunteer labor

Cons: very labor intensive over short duration, transport logistics, permitting for large deployments can be challenging

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